

Research Paper No. 7

**An Econometric Model of the Edmonton Economy:
The Output, Employment and Wage Modules.**

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Important Note

This Technical Paper has been prepared by the Corporate Forecasting Group, Long Range Planning Branch, Planning and Building Department. The paper documents research results as part of an ongoing forecasting activity. Neither the methods or results have been endorsed by the City of Edmonton.

October, 1986

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Acknowledgment

We wish to thank Harvey Crone, Jong Huang and other members of the Corporate Forecasting Group for having reviewed this paper.

Special thanks is also extended to the Word Processing Unit for having typed several drafts.

Executive Summary

Introduction

This report documents the equations to be used for the output, employment and wage modules of an econometric model for Edmonton.

Part one of the paper is devoted to a review of the theoretical and empirical literature on regional and urban macroeconomic models. In part two, a theoretical framework is developed. Section three is concerned with estimating structural equations for the output, employment and wage rate modules. Finally, part four discusses future work on the econometric model.

1. Literature Review

A. Theoretical Studies

Klein (1969)

It is suggested that regional models should be built along the lines of national models and consist of endogenous regional variables, exogenous regional and national variables. The objective is to use the output from the national model to drive the local model.

Rubin (1981)

Output is disaggregated into manufacturing, non-manufacturing and government sectors. All manufacturing output is assumed to be exported from the region.

B. Empirical Studies

Output

Industrial activity in the region is usually separated into local and national activity. Local activity is defined as output that is produced for the local market. As a result, the output variable is tied to local economic and demographic variables. On the other hand national activity is linked to variables outside of the region. In some cases output is tied to both local and national activity.

Labour demand and supply

The demand for factors of production is derived from the demand for consumer and producer goods. As a result, inverted production functions are used to derive employment equations.

The supply of labour is normally calculated by multiplying the labour force participation rate by the working age population. The labour force participation rate is specified as a function of the wage rate, income per capita and the percentage of the population that is female and between the ages of 20 to 64 years.

Prices and Wages

The local wage and price level was observed to be influenced by local and national conditions.

2. Model Specification

Output	The model is divided into six industrial divisions: manufacturing, trade, finance, service, transportation and construction.
Manufacturing	Manufacturing is assumed to be a function of the Canadian Gross National Expenditures the regional disposable income per capita, the regional population and the ratio of the Edmonton wage rate to the Canadian wage rate.
Trade	Trade is a function of the disposable income per capita, population, the prime interest rate and the gross domestic product price deflator.
Finance	Finance is a function of the disposable income per capita, population, the prime interest rate and the net capital expenditures in the energy industry.
Services	Services is assumed to be a function of income per capita, population, the gross domestic product deflator and the net capital expenditures in the energy industry.
Transportation	Transportation is a function of population, disposable income per capita, manufacturing output and time.
Construction	Construction is a function of lagged building permits.
Employment	Employment is a function of output, previous employment, the wage rate, capital and productivity.
Wage rate	The regional wage rate is a function of unemployment, the national wage rate and the regional consumer price index.

3. Estimated Equations and Output, Employment and Wage Rate

Statistical relationships were established between the following dependent and independent variables:

Dependent	Independent
<u>Output</u>	
Manufacturing	Relative wage, Canadian Gross National Expenditures
Trade	Alberta Population and Alberta disposable income per capita.
Finance	Net capital expenditures in the energy industry and Alberta Population.

Services	Alberta disposable income per capita, Alberta population and net capital expenditures in the energy industry.
Transportation	Regional population, manufacturing output and time.
Construction	Building permits of the previous period, building permits of the previous two periods.

Employment

Manufacturing	Manufacturing output, productivity in manufacturing.
Trade	Trade output, time.
Finance	Finance output, productivity in finance.
Services	Time, services output.
Transportation	Transportation output, productivity in transportation.
Construction	Construction output, productivity in construction.

Wage Rate

Manufacturing	Wage rate in Canadian manufacturing, local unemployment rate.
Trade	Local consumer price index of the previous period, local unemployment rate.
Finance	Local consumer price index of the previous period, local unemployment rate.
Services	Wage rate in Canadian services, local unemployment.
Transportation	Local consumer price index of the previous period, local unemployment rate.
Construction	Local consumer price index of the previous period, local unemployment rate.

4. **Future Work**

The estimated equations for the output, employment and wage modules will be grouped with equations from other modules to form an Edmonton econometric model. The next stage in the research process will be to simulate the entire model in order to provide an estimate for the sample period, 1971-1984. If the model produces acceptable results, then forecasts will be developed for future time periods.

Introduction

In March 1986, the Corporate Forecasting Group initiated a project to develop an econometric model for the City of Edmonton. The model when completed will be used for the following purposes:

- i) to prepare consistent, integrated economic forecasts of the Edmonton economy for use by the City Forecast Committee;
- ii) to assess the impact of changes in the external environment on Edmonton's key economic indicators, and quantify the economic implications of alternative policy options; and
- iii) to develop a greater understanding of the Edmonton economic structure.

The current report is part of this larger project, since it documents the equations to be used in the output, employment and wage rate modules. The paper is divided into four parts. Part one is devoted to a review of the theoretical and empirical literature on regional and urban macroeconometric models. In the second part a theoretical framework is developed for the proposed modules. Section three is concerned with estimating the structural equations for output, employment and wage rate. Finally in part four, future work on the econometric model will be discussed.

Part I: Literature Review

The publication of J.M. Keynes' (1936) path breaking study on national economic stabilization, The General Theory of Employment Interest and Money, laid the foundation for most of the later theoretical and empirical work in macroeconomics. Not surprisingly the first macroeconometric models were developed for the national economy. Jan Tinbergen (Theil et al 1965) is often credited as being the first economist to build an econometric model of the national economy. In his studies for the League of Nations (Tinbergen 1939), he presented a model of the United States economy. This was followed by the Klein and Golberger (1955) prototype model of the U.S. economy and numerous other models (Duesenberry et al 1965 and Evans et al 1968). In Canada, macroeconometric modelling efforts were spearheaded by the Bank of Canada and the Economic Council of Canada resulting in the development of the RDXF and CANDIDE models, respectively, and their many variants.

After some delay econometric models appeared at the state level. (Research Seminar in Quantitative Economics 1965, Burton and Dykman 1967, and L'Esperence et al 1969) and similar models have been developed for Canadian provinces. (Fine and Nagarajan, Mansell and Wright 1981 and Schweitzer 1982).

The prototype model for an urban economy was developed by Glickman (1971) for the Philadelphia metropolitan area. Glickman's formulation is based on Klein's (1969) structure, which states that a regional model can use a national forecast obtained from a national model. The Glickman (1971) system is a 26 equation model, which is estimated on the basis of annual data in a block recursive system. The first block contains equations for output, employment and wages for each of three sectors: manufacturing, non-manufacturing and government. It also contains interdependent equations for the estimation of gross regional product, personal income, consumption expenditures, consumer prices, labour force and population. The second block is made up of a small government sector. This is used to estimate local government expenditures and revenues.

This model suffers from a number of limitations:

- a) lack of dynamics
- b) reliance on the use of time as a proxy variable
- c) output is very aggregated, and
- d) supply and demand equations are not specified in the output sector.

Glickman's ideas have served as the basis for later modelling efforts (see Glickman 1977, Rubin et al 1980, Rubin 1980, Duobinis 1981 and Baird 1983).

Several attempts were made to identify relevant Canadian studies on urban macroeconomics, with two studies reviewed. (Miron 1975 and Ochitwa 1982). The Miron (1975) study is a review of articles on urban growth. Most of the papers were for the U.S. and as a result, it was not possible to learn about Canadian data sources. The Ochitwa (1982) study is a master's thesis completed at the University of Alberta; this study does not use data to develop its theories and, as a result, has only limited application in the model building efforts for Edmonton.

This segment is divided into two areas: theoretical studies and empirical studies.

1. Theoretical Studies

The publication of Klein's (1969) guidelines on the proper construction of regional macroeconomic models has kindled researchers curiosity in this area and as a result, this study will be reviewed. In addition, a more recent work (Rubin 1981) will be surveyed.

1A. Klein

Klein (1969) recommended that regional macroeconomic models should be built along the lines of national models and consist of endogenous regional variables, exogenous regional variables and national variables. The national variables could be endogenous or exogenous to both local and national models, or they could be produced as endogenous variables from a national model. The objective is to use the output from the national model to drive the local model.

His ideal model is built around a form of the Keynesian identity. Money gross regional product is defined as the product of the implicit price deflator and the real gross regional product. The components of money gross regional product (PGRP) are as follows:

$$PGRP = PcC + PII + GSL + GF + PxX - PmM$$

Where:

P	=	general price level for the nation
C	=	real regional consumption
I	=	real investment
GSL	=	regional and state government expenditure
GF	=	federal government expenditure
X	=	real regional exports
M	=	real regional imports
Pc	=	regional price deflator for consumption
PI	=	regional price deflation for investment
Px	=	regional price deflator for exports
Pm	=	regional price deflator for imports

Real consumption (C) is expressed as a function of real disposable income (Y_t/P_c).

$$C = C(Y_t/P_c)$$

is based on the hypotheses that:

- a) real consumption is positively related to real disposable income, and
- b) a unit change in income will produce a change in consumption that is less than a unit.

Disposable income (Y_t) is defined as the difference between gross regional product (PGRP), state-local taxes (TSL), federal taxes (TF) and depreciation (D).

$$Y_t = PGRP - TSL - TF - D$$

The investment function is based on a form of the accelerator principle where investment (I_t) is related to real gross regional product (GRP), real interest rate (R) and the previous period's capital (K_{t-1}).

$$I_t = I(GRP, K_{t-1}, R)$$

The hypothesized relationships between the dependent and independent variables are as follows:

- a) investment is positively related to the gross regional product and the previous period's capital stock, and
- b) there is a negative correlation between the interest rate and regional investment.

Real regional imports (M) are linked to the real gross regional product and the ratio of the national gross domestic product deflator P to the import price deflator P_m .

$$M = M(GRP, P/P_m)$$

M is expected to be positively related to both GRP and P/P_m .

Real regional exports (X) is a function of real gross domestic product (GDP) for the nation and the ratio of the gross national product deflator (P) to the export price deflator (Px).

$$X = X(\text{GDP}, P/P_x)$$

The above formulation is based on the assumption that exports are sent to the rest of the nation and as a result, exports are expected to be positively related to both GDP and P/P_x .

The regional price variables (P_i) are tied to local and national conditions. Prices (P_i) are assumed to be a function of the national GNP deflator (P) and the local wage rate (W).

$$P_i = P(P, W)$$

where $i = X$ and C ,

P and W are expected to be positively correlated with P_i .

The wage rate is assumed to be a function of the national unemployment rate (UN), the regional unemployment rate (U) and consumer prices (P_c).

$$W = W(\text{UN}, U, P_c)$$

The above relationship is a form of the Phillips curve, since the wage rate is expected to be negatively related to UN and U rates and positively related to P_c .

The model has some short comings:

- a) It is theoretical in nature and as a result, little attention was paid to its estimation; for example at the regional level, governments do not have procedures in place to gather data on regional imports and exports. As a consequence, it will not be possible to estimate import and export equations.
- b) The model is very aggregated in nature, since it sums industrial activity into one output and treats it as though it is produced by a single firm and as a consequence, it does not help us to understand the complex interrelationships in a modern economy.

Klein's model is based on the assumption that economic activity at the local level is influenced by both local and national factors. This approach is different to that adopted in the earlier macroeconometric models, (see discussion in Glickman 1977) where all local economic activity was linked to national economic activity. For example retail trade in Michigan was linked to U.S. automobile expenditures, and therefore it ignores factors such as the local personal disposable income.

1.2. Rubin's Study

Rubin (1981) differed from Klein (1969) in that he used an approach that disaggregated regional income into manufacturing wages, non-manufacturing wages, government expenditures and non-wage income.

$$PY = (WM.EM) + (WNM.ENM) + (WGV.EGVPC.POP) + NWY$$

where:

PY	=	personal income
WM	=	wage rate in manufacturing
EM	=	employment in manufacturing
WNM	=	wage rate in non-manufacturing
ENM	=	employment in non-manufacturing
WGV	=	wage rate in government
EGVPC	=	employment in government per capita
NWY	=	non wage income
POP	=	the regional population

The regional manufacturing wage rate (WM) is related to the national manufacturing wage rate (WMUS), the regional consumer price index (CPI), and the regional unemployment rate (UNR).

$$WM = W(WMUS, CPI, UNR)$$

This formulation is based on the assumption that wages are formed by local and national conditions. National standards and regulations affect the local labour market through minimum wage laws and unionization. Local conditions are represented by the level of consumer prices (CPI) and labour market conditions (UNR).

Output in the regional manufacturing sector (QM) is assumed to be a function of the national manufacturing output (QMUS), regional personal income (PY), investment in manufacturing (IM) and the relative unit labour cost in manufacturing (RULC).

$$QM = Q (QMUS, PY, IM, RULC)$$

Rubin assumes that manufacturing output is exported to the rest of the nation and as a consequence, the endogenous variable (QM) is linked to national activity (QMUS).

In the non-manufacturing sector regional output (QNM) is related to the regional population (POP), regional personal income (PY), regional consumer price index (CPI) and the regional unemployment rate (UNR).

$$QNM = Q (POP, PY, CPI, UNR)$$

Non-manufacturing output is assumed to be produced for local consumption, and output is thus linked to local activity.

Employment is derived by an inverse production function (Rubin et al 1980). A constant elasticity of substitution production function is utilized so that wages can be incorporated explicitly into the expression.

In the manufacturing sector regional employment (EM) is related to regional manufacturing output (QM), regional employment of the previous period in manufacturing (EML1), the regional manufacturing wage rate (WM), the regional productivity in the manufacturing sector (PRDM) and capital in the regional manufacturing sector (KM).

$$EM = E (QM, EML1, WM, KM, PRDM)$$

Employment in the regional non-manufacturing sector is a function of the regional non-manufacturing output (QNM), the previous employment in the non-manufacturing sector and the wage rate in the regional non-manufacturing sector (WNM).

$$ENM = E (QNM, ENML1, WNM)$$

The regional consumer price index (CPI) is hypothesised to be a function of its national equivalent (CPIUS) and the regional unemployment rate (UNR).

$$CPI = C(CPIUS, UNR)$$

In this formulation, it is assumed that inflation is caused by both local and national factors.

Rubin's (1981) model is an improvement over Klein's (1969) formulation, since it was developed with the specific purpose of being used as a framework by the 'non-economist' to develop econometric models for urban areas. As a result, Rubin paid a good deal of attention towards making the model operational. For example, in addressing the question of imports and exports, the author assumed that manufactured goods were exported and non-manufacturing was for local consumption. Manufacturing was related to national variables and non-manufacturing to local variables.

The model is limited, in that, it fails to recognize that some output is produced for both local and national markets (see Glickman 1977 and Rubin et al 1980). In addition the author fails to say whether or not the output equations are demand, supply or reduced from equations (see Baird 1983 and Duobinis 1981).

2. Empirical Studies

In this section several macroeconometric models are reviewed for the sub-national level. The analysis covers state (Baird 1983), provincial (Mansell et al 1981) and metropolitan (Glickman 1971 and 1977, Duobinis 1981 and Rubin et al 1980) area models. These studies all draw on the pioneering efforts of Glickman (1971). The rest of this section is divided into the following topics: output, labour market, prices and investment.

2.1. Output

Glickman's (1971) specification of industrial activity is based on the assumption that manufacturing output is exported from the region. As a result, regional manufacturing activity was tied to the national Gross Domestic Product (GDP). Similarly the output from the non-manufacturing sector was assumed to be consumed in the local economy. By employing this assumption, he is able to incorporate exports into the model and utilize a

form of the export base theory. However, this line of reasoning overlooks the fact that some forms of manufacturing activity is for local consumption or both local and national consumption. Glickman (1977) in an expanded model of the Philadelphia regional economy corrected this short coming.

Through the use of an input-output table of the Philadelphia economy, he was able to identify the flow of goods and services among industries and the rest of the nation. This approach has since been adopted by other researchers (see Rubin et al 1980 and Duobinis 1981).

Stemming from Glickman's (1977) analysis, three types of industrial activities are identified: local, national and national/local. Examples of these equations are as follows:

Local

$$QP = a_0 + a_1 POP + a_2 QPL1$$

where:

QP = regional output

POP = regional population

QPL1 = regional output for the previous period

National

$$QP = a_0 + a_1 NPOP + a_2 NQPL1$$

where:

NQPL1 = output from the corresponding national industry for the previous period

NPOP = national population

National/Local

$$QP = a_0 + a_1 NPOP + a_2 NQPL1 + a_3 QP_2$$

where:

QP = regional output

NQPL1 = output from the corresponding national industry for the previous period

NPOP = national population

QP₂ = regional output from another industry 2

In spite of these changes, the model (Glickman 1977) was criticized for lacking proper structure. Duobinis (1981) also contended that output in the various sector is specified by a single equation. As a result, it is not possible to say whether or not these equations represent demand or supply relationships. In addition there is no indication as to whether or not these specifications represent reduced form equations. This problem has been addressed by Duobinis (1981) and Baird (1983). Following Duobinis, the demand for a representative industry's output is specified in logarithmic form as:

$$\ln QP = \ln a + a_1 \ln P_t + a_2 \ln PY + a_3 \ln NQP$$

where:

QP_d = the demand for output

P = the price for output

PY = local activity level, represented by the income of consumers of the product.

NQP = national activity for the corresponding industry.

$\ln$ = natural logarithm

The main elements in a supply equation are output, output price and factor price. In attempting to capture this relationship Duobinis specified a transcendental logarithmic (translog) cost function. (For a discussion see Christensen et al (1973)). He argues that a translog function is less restrictive than the Cobb-Douglas and the Constant Elasticity of Substitution production functions, since it is less likely to lead to inappropriate assumptions. This view is supported by Baird (1983). However, when Baird comes to specify her own supply equations, she opts for a Cobb-Douglas type of equation, arguing that the translog equation is intractable.

2.2. Labour Market

The labour sector is normally comprised of equations for labour demand, labour force participation rate, net migration and identities for labour supply, population and the unemployment rate.

I Labour Demand

The demand for all factor inputs is derived from the demand for commodities. As a result, the theoretically correct method for estimating labour demand functions is to derive demand equations from production relationships. Ghali and Renaud (1975) argue

that there is no real advantage to be gained from using a complex production function such as the constant elasticity of substitution (CES) production function over a more simple production function such as the Cobb-Douglas (C-D) production function.

In specifying a labour demand function for the Alberta economy, Mansell and Wright (1981) and Teconomics use an inverted Cobb-Douglas production function.

$$RQ = Ae^{RT} RK^a E^B, a + B = 1$$

where:

- A = a scalar
- e = the base of Napierian logarithms
- R = the rate of neutral technological progress
- T = time
- RK = capital
- E = employment
- a, B = the elasticities of output with respect to capital and labour respectively.

Putting the above equation into logarithmic form and inverting it, the labour demand equation is stated as:

$$\ln E = -(1/B) \ln A - (R/B)T - (a/B) \ln R/K + (1/B) \ln RQ$$

The labour supply equation (LS) is usually stated as the product of the labour force participation rate (LFPR) and the working age population (WPOP).

$$LS = LFPR \times WPOP$$

In their Alberta model Mansell and Wright (1981) used Bowen and Finegan's (1969) work in specifying their labour force participation rate equation.

$$LFPR = L(RYPCL1, ANURL1, FEM)$$

where:

- RYPCL1 = real per capita income in the previous
- ANURL1 = provincial unemployment rate in the previous period
- FEM = percentage of the population which is female and between the ages of 20 to 64.

II Population

Rubin (1981) relates population (POP) to the natural increase population (NTINC), personal income PY and the regional unemployment rate (UNR).

$$POP = P (NTINC, PY, UNR)$$

In the Alberta models (Wright and Mansell 1981, Teconomics Schweitzer 1982) population is projected by using the cohort survival technique.

III Net Migration

Net migration provides the link between population and the labour market. The literature on economic induced migration is very exhaustive (for a survey see Greenwood 1975). The usual practice when specifying net migration equations is to assume that migrants attempt to maximize the present value of their expected lifetime income (Sjaastad 1962). In the case of Alberta, Mansell and Wright (1981) specified the following equation:

$$NM = a_0 + a_1 RRYPC + a_2 NML1 + a_3 RI + a_4 RUNR$$

where:

NM = net migration

RRYPC = real per capita income in Alberta

RI = rate of real investment in Alberta

RUNR = the ratio of the unemployment rate in Canada, to the unemployment rate in Alberta.

Huang (1986) in estimating regression equations for the City of Edmonton uses a similar line of reasoning. Net migration is linked to Alberta's real gross domestic product GDP, total employment EDEMP and Alberta's unemployment rate relative to Canada's rate. These relationships are captured in a five equation model.

IV Prices and Wages

Wages

Glickman (1971) relates money wages (MAW) to the regional unemployment rate (UNR) and the national wage rate for the corresponding industry (NMAW)

$$MAW = M (UNR, NMAW)$$

Rubin (1981) uses similar logic to Glickman's, but allows for the addition of the regional consumer price index (CPI).

Prices

Glickman (1971) states that the general price level (CPI) is a function of the ratio of the total wage bill (TWB) to the gross regional product (GRP) and the total regional employment (TEMP).

$$CPI = C (TWB/GRP, TEMP)$$

The above formulation assumes that the regional price level is locally determined. This ignores the fact that the region is not self contained, and that it conducts a considerable amount of its trade with the rest of the nation. Rubin (1981) recognizes this and incorporates a variable to represent the national price level (CPIUS).

$$CPI = C (TWB/GRP, TEMP, CPIUS)$$

V Investment

Net investment (IN) is defined as the change in the current capital stock (K_t) over the previous period's capital stock K_{t-1} .

$$IN = K_t - K_{t-1}$$

Gross Investment (IG) is the sum of net investment (IN) plus replacement investment (IR).

$$IG = IN + IR$$

Krueckeberg and Silvers (1974) hypothesize that net investment in the regional economy (IN) is related to value added (Y_t) and the previous period's capital stock (K_{t-1}).

$$IN = a_0 + a_1 Y_t - a_2 K_{t-1}$$

Glickman (1971) uses similar logic to describe investment behavior in the firm, but allows lagged investment to be an independent variable (I_{n-1}).

$$IN = a_0 + a_1 Y_t - a_2 K_{t-1} + a_3 I_{n-1}$$

Conclusion

The regional econometric models that were reviewed are based on the structure proposed by L.R. Klein (1969). This allows regional models to be linked to national models, and as a consequence national forecasts are allowed to drive the local variables. In addition the models are simultaneous in nature and are therefore able to duplicate the economic and demographic linkages in the society.

The specific conclusions that arise from the literature survey are as follows:

1. Output

Industrial activity in the region is usually separated into local and national activity. Local activity is usually defined as output that is produced for the local market. As a result the output variable is tied to local economic and demographic variables. On the other hand national activity is linked to variables outside of the regions boundaries. In some cases output is tied to both local and national activity.

2. Factors of Production

- Demand

The demand for factors of production is specified as being derived from the demand for consumer goods. As a consequence input demand is tied to consumer output.

- Supply

a) Labour

The supply of labour is normally calculated by multiplying the labour force participation rate by the working age population. The labour force participation rate is specified as a

function of the wage rate, income per capita and the percentage of the population that is female and between the ages of 20 to 64 years.

b) Capital

Capital is usually expressed by the identity.

Present Capital = previous periods capital + investment

Investment is a function of output, previous capital stock and the rate of interest.

3. Prices and Wages

Prices and wages are tied to national and local variables.

Part 2: Model Specification

The model is divided into six industrial divisions, with the breakdown dictated by existing data sources. Time series data on wages and employment for the Edmonton C.M.A. is available for manufacturing, trade, finance, service, transportation and construction, and thus, estimates for output can only be made for those sectors. Output in each industrial division is represented by an equation.

1. OUTPUT

A. Manufacturing

Following Glickman (1971), manufacturing output is assumed to be exported from the region to the rest of the nation. As a consequence, local manufacturing activity is tied to national economic activity, so that an increase in the Canadian Gross National Expenditure (GNE) is expected to have a positive effect on the regional manufacturing industry (M). As well, some of the manufacturing output is consumed locally and as the local consumers' disposable incomes (DYPC) increase, the demand for manufactured goods is expected to rise. The extent of the local manufacturing market is determined by the size of the regional population (MPOP). As the local population grows, the demand for manufactured outputs is expected to increase.

The location of a manufacturing plant is influenced by the relative availability of factors of production (Rubin 1981). The greater a factor's relative scarcity, the greater will be its relative price, for example, if labour is more abundant in Edmonton than Calgary, then the wage rate in Edmonton should be lower than the wage rate in Calgary. In the present analysis the scarcity of production factors is represented by the Edmonton to Canada wage rate ratio (ECANWR). As the ratio increases, factories are more likely to be located in locations other than Edmonton.

The above relationships are captured by the following equation:

$$M = M(GNE, DYPC, MPOP, ECANWR); \text{ with } \\ M'_{GNE} > 0, M'_{DYPC} > 0, M'_{MPOP} > 0, \text{ and } M'_{ECANWR} < 0$$

B. Trade

Consumers are expected to increase their demand for traded output as their disposable income increases. The regional (DYPC) or provincial (ALTDYPC) disposable income per capita is used to estimate consumers purchasing power.

As the size of the market expands, the demand for traded output is likely to increase. Market size is estimated by the regional (MPOP) or provincial (ALTPOP) population.

The quantity demanded of traded output is expected to be negatively related to the price of tradeables. An increase in their prices will result in consumers reducing their purchases. The average price of tradeables is represented by the gross domestic product deflator (DEFL).

Consumers and businesses often finance their purchase of goods and services through loans from financial institutions. The cost of these funds is measured by the rate of interest (INT). A decrease in the rate of interest is expected to have a positive impact on the purchase of tradeable goods.

Tradeable output is therefore represented by the following equation:

TRADE = T(DYPC or ALTDYPC, MPOP or ALTPOP, INT, DEFL); with
 $T'_{DYPC} > 0$, $T'_{MPOP} > 0$, $T'_{ALTDYPC} > 0$, $T'_{ALTPOP} > 0$, $T'_{INT} < 0$, and $T'_{DEFL} < 0$.

C. Finance

Consumers and businesses divide their income between consumption and savings and thus an increase in income should create a demand for more financial services. The expected relationship between financial output and disposable income is positive.

The extent of the financial market is estimated by the size of the region's population. As the population increases, the demand for financial services should increase. Edmonton's role as a financial centre extends beyond the boundaries of the region. This feature of the region's role can be accounted for by including the

province's population as an explanatory variable. The estimated sign for this variable is expected to be positive.

Financial institutions are expected to increase their services to the public as interest rates increase and decrease them as interest rates fall. On the other hand consumers are expected to exhibit the opposite behaviour. The expected sign of this variable is therefore an empirical question.

Energy development has played a pivotal role in Edmonton's economic development. As a result, capital expenditures in the energy sector is expected to create a demand for financial service. The statistical relationship between capital expenditures in the energy sector and financial services is expected to be positive.

Economic activity in the financial sector is therefore represented by the following equation:

$$F = F(\text{DYPC or MPOP or ALTPOP}, \text{ALTDYPC}, \text{RINT}, \text{NCEP})$$

$$F'_{\text{DYPC}} > 0, F'_{\text{MPOP}} > 0, F'_{\text{ALTPop}} > 0, F'_{\text{ALTDYPC}} > 0, F'_{\text{RINT}} < 0, F'_{\text{NCEP}} > 0$$

Where DYPC = Regional disposable income per capita
MPOP = Regional population
ALTPop = Alberta population
ALTDYPC = Alberta disposable
RINT = Real interest rate
NCEP = Net capital expenditures

D. Services

Consumers increase their demand for services as their personal disposable income increases. In this analysis, Edmonton C.M.A.'s disposable income per capita (DYPC) is used to estimate a consumer's income. The extent of the market for services is estimated by the size of the regional population (MPOP).

On the other hand the demand for services is expected to be negatively correlated with the average price level for services. The average price level is represented by the Gross Domestic Product deflator (DEFL).

Edmonton is a service centre for businesses and the oil industry is a major customer in this sector (Mansell et al 1981). As a result, expenditures in that industry (NCEP) will be positively correlated to the output from the service industry.

The above relationships are represented the following equation:

$$\text{SERVICE} = S(\text{ALTDYPC}, \text{ALTPOP}, \text{DEFL}, \text{NCEP}); \text{ with } S'_{\text{DYPC}} > 0, S'_{\text{MPOP}} > 0, S'_{\text{DEFL}} < 0, \text{ AND } S'_{\text{NCEP}} > 0$$

Net capital expenditures in the petroleum industry can be estimated by the equation:

$$\text{NCEP} = N(\text{WOLP}, \text{NCEPL1}, \text{RINT}); \text{ with } N'_{\text{RWOLP}} > 0, N'_{\text{NCEPL1}} > 0, N'_{\text{RINT}} < 0$$

Where WOLP = World oil prices
 NCEPL1 = Net capital expenditures of the previous period
 RINT = Real interest rates

Capital expenditures are usually financed from a company's cash flow and this is increased or decreased by corresponding changes in oil prices. As a result, capital expenditures are expected to be positively related to oil prices.

In some cases capital expenditures are financed through external sources. The cost of capital to the firm is the rate of interest. It is expected that the rate of interest will be negatively correlated with net capital expenditures.

Businesses often try to maintain past levels of expenditures which is represented in the above equation by lagged capital expenditures. It is hypothesized that past and current expenditures will be positively correlated.

E. Transportation

The demand for transportation services is expected to increase as consumers disposable income increases. The size of the market is measured by the region's

population. As a result, it is hypothesized that transportation output and population will have a positive relationship.

Edmonton is the province's second largest city, and not surprisingly a major portion of the transportation industry is located here. An increase or decrease in the province's economic activity will have a significant effect on the transportation industry.

The transportation industry provides services to other industries, especially the goods producing sector. The manufacturing output variable is used to capture this effect. It is hypothesized that transportation output and manufacturing output will be positively correlated.

Over the last decade, the communication sector of the transportation industry has increased in importance. This is due to the development of the micro-electronic technology and national data bases. In order to capture this development, YEAR is included as an independent variable. The expected sign on its coefficient is positive.

As a result, transportation output can be estimated by the following equation:

$$TT = TT(MPOP, DYPC, ALTGDP, M, YEAR); \text{ with} \\ TT'MPOP > 0, TT'DYPC > 0, TT'ALTGDP > 0, TT'M > 0, TT'YEAR > 0$$

Where MPOP = Regional population
 DYPC = Regional disposable income per capita
 ALTGDP = Alberta's Gross Domestic Product
 M = Manufacturing output
 YEAR = Time

F. Construction

Construction output is estimated by the following equation:

$$CONST = C(BL1, BL2); \text{ with} \\ C'BL1 > 0 \text{ and } C'BL2 > 0$$

Where BL1 = Building permits of the previous period
 BL2 = Building permits of two previous periods

The expected sign on both variables is positive (see discussion on building permits in discussion paper No. 4).

2. EMPLOYMENT

The theoretically correct way for estimating a labour demand equation is to use an inverted production function, since the demand for labour is derived from the demand for goods and services. Since there are several types of production functions to select from, the choice of a given production function is determined by the researchers preference or by data availability and experimentation.

Following Rubin (1981) the employment equation is specified as:

$$E = E(Q, EL1, W, K, PRD, YEAR); \text{ with} \\ E'Q > 0, E'EL1 > 0, E'W < 0, E'K > 0 \text{ and } E'PRD < 0$$

Where Q = Output for the given industry
 EL1 = Employment from the previous period
 K = Capital
 PRD = Productivity
 W = Wage rate
 YEAR = Time

Employment in a given period is influenced by employment of the previous period. In some occupations changes in employment tends to respond very sluggishly to economic fluctuations. Oi (1963) has argued that training is a form of capital investment and that the greater an employee's training the less likely that employee will be laid off during an economic recession. Current employment should therefore be positively correlated to previous employment. The trend in employment is also represented by the variable YEAR. The correlation between this variable and the dependent variable is expected to be positive.

The wage rate is the price that the firm pays for labour. An increase in the wage rate represents an increase in cost for the firm. Assuming that the entrepreneur is a profit maximizer/cost minimizer, the relationship between employment and the wage rate is expected to be negative.

Assuming all things are equal, an increase in output will result in an increase in the demand for factors of production. As a result, employment is expected to be positively related to either output or capital or both.

The production process, over time, is influenced by technological change and therefore an improvement in technology may result in the firm reducing its demand for either capital or labour or both. Technological change in the current exercise is measured by the ratio of output of the previous period to current employment. This ratio is referred to as productivity. It is expected that productivity and employment will be negatively related.

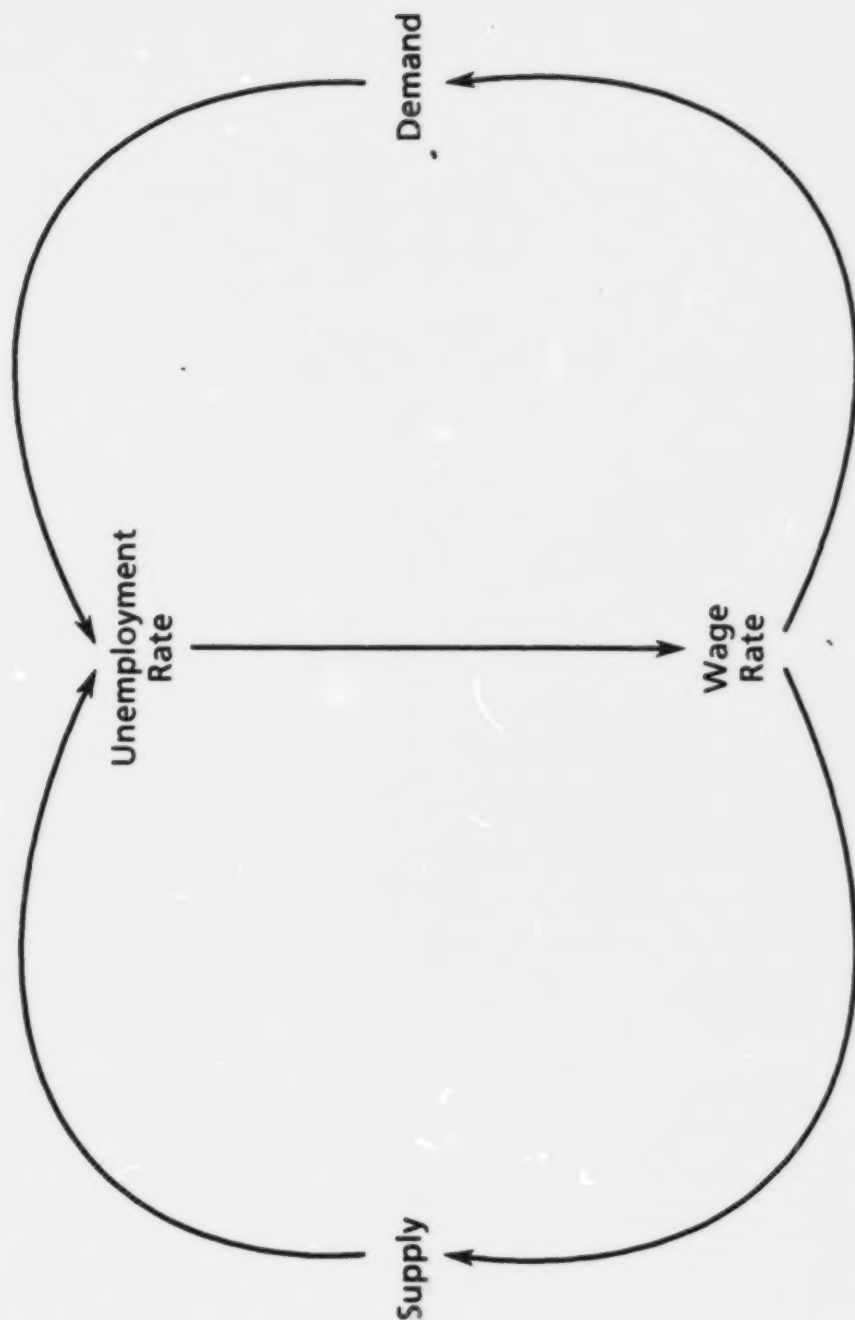
3. WAGES

The wage rate is the price of labour. As with other prices, the wage rate is influenced by the demand and supply for labour. Because of market imperfections, the market (or theoretical) price tends to deviate from the actual (or observed) price in the short run.

The relationship between demand and supply is sketched out in Figure 1. The market is shown as a closed system consisting of two feedback loops: demand and supply. These components are linked together by the wage rate and the unemployment rate.

If the quantity of labour is increased, assuming all things are equal, the unemployment rate increases, wages are therefore bid downwards. This reduces the quantity of labour supplied. On the other hand, a lower wage rate tends to increase the quantity of labour that is demanded. A reduction in the quantity of labour supplied and an increase in the quantity of labour demanded both combine to reduce the unemployment rate. A reduction in the unemployment rate will produce the reverse effect on the wage rate. The expected statistical relationship between unemployment and the wage rate is negative.

Figure 1
Wage Formation



The characterization of the market as a closed system is at odds with reality, since the market is often subjected to external shocks. These disturbances occur because of trade or some form of communication with the rest of the nation or the world. For example in labour relations, there is pattern bargaining, where local unions try to follow national or local trends in wage and benefit settlements. These influences will be represented by the national wage rate and/or the regional consumer price index. The estimated sign of the parameters is expected to be positive.

The wage formation process is represented by the following equation (Klein 1969):

$$W = W(U, W_n, CPI)$$

$$W'_u < 0, W'_{wn} > 0 \text{ and } W'_{CPI} < 0$$

where

U = the local unemployment rate

W_n = the national wage rate

CPI = the local consumer price index

Part 3: Model Estimation

METHODOLOGY

The equations used to estimate output and employment are developed in two stages;

- a) the theoretical underpinnings for the various output and employment equations are established (in part 2), and
- b) the theoretical equations are tested and estimated using the ordinary least square (OLS) statistical technique.

The general form of the empirical equation is as follows:

$$Y = a + b_1x_1 + b_2x_2 \dots + b_mx_m + E$$

Where Y = the dependent variable

a = the vertical intercept

b_i = the structural coefficient of the i th independent variable

x_i = the i th independent variable

E = the error term

The ordinary least square (OLS) method is used so as to estimate the statistical relationships between the dependent variable (Y) and the independent variables (x_i) in the equation.

The size and significance of these relationships are tested by the following statistics:

- a) the "t" statistic
- b) the coefficient of multiple determination, R^2
- c) the Durbin-Watson statistic.

The "t" value measures the statistical relationship between the independent variable (x_i) and the dependent variable (Y). The computed "t" value is compared against the table value of the "t" statistic. If the (absolute) value of the "t" statistic is greater than the table value, the null hypothesis that the estimated coefficient b_i is not different from zero is rejected.

The R^2 , or coefficient of multiple determination measures the percentage of variance in the dependent variable (Y) that is explained by variations in the independent variables (x_i) as a group.

The Durbin-Watson statistic is used to test for the presence of autocorrelated residuals. Durbin-Watson statistics close to 2 indicate a lack of autocorrelation. This measure is employed to check on the reliability of the estimated parameters.

Data

In order to estimate econometric equations for the City of Edmonton, data of adequate quantity and quality must be obtained. Time series data for economic accounts is available only at the national and provincial levels. Estimates had to be made of output for each industrial division in Edmonton C.M.A. by adjusting the provincial data.

The output for a given industrial division for Edmonton C.M.A. was estimated as follows:

- a) Calculate the Edmonton C.M.A.'s total wage bill for a given industrial division by multiplying the industry's average wage rate by the total employment. This produces the Edmonton C.M.A. total wage bill for that industry.
- b) Calculate the Provincial total wage bill for the corresponding provincial industry. The procedure is the same as in the case of Edmonton C.M.A.
- c) Divide result a by result b. This gives the ratio of the Edmonton C.M.A. total wage bill to the provincial total wage bill for a given industry.
- d) Multiply the result from step c by the provincial output for the given industry. The result is the estimated industrial output for the given industry in the Edmonton C.M.A.

Empirical Results

The estimated equations were based on the theoretical relationships that were specified in the previous section. Several of these equations had to be altered so as to correct for various statistical problems.

The following are the estimated equations:

		R ²	SEE	DW
1.	<u>OUTPUT</u>			
A.	<u>Manufacturing</u>			
	M = 220.44-356.26ECANWR+.00399GNEL1	.816	22.43	1.45
	(2.50) (-2.99) (6.35)			
B.	<u>Trade</u>			
	T = -581.95+.33525ALTPOP+.09811ALTDYPC	.907	28.43	1.86
	(-4.82) (8.04) (2.45)			
	-19.00 RINTL1			
	(-4.35)			
C.	<u>Finance</u>			
	F=-21.14+.02908NCEP+.11157ALTAPOP	.90318	20.38	1.65
	(-.37)(2.88) (2.85)			
D.	<u>Services</u>			
	S=-65.54+.02062ALTDYPC+.05355ALTPOP	.992	4.75	1.62
	(-1.95)(2.35) (5.20)			
	+.0313NCEP			
	(9.94)			
	NCEP = 1256.17+42NCEPL1+91.8WOLP	.948	221.61	1.32
	(1.76) (2.04) (2.32)			
E.	<u>Transportation</u>			
	TT = -30880.55+.945MPOP+.471M+15.53YEAR	.99	17.26	1.49
	(2.15) (2.25) (3.28) (2.10)			

F. Construction

$C = 19.886 + 0.5865BL1 + 0.1557BL2$	.90	26.67	1.21
(0.85) (4.76) (1.28)			

2. EMPLOYMENT

A. Manufacturing

$EM = 12.68 + .0512M - .459PRDM$	.91	.74	2.41
(7.61)(10.7) (3.69)			

B. Trade

$ET = 1274.17 + .035T + .655YEAR$	.97	1.09	2.25
(-4.97)(5.02) (5.32)			

C. Finance

$EF = 6.52 + .034F - .2PRDF$	.97	.45	2.64
(5.00) (18.05) (-5.57)			

D. Services

$ES = -328.4 + .168YEAR + .099S$	.99	.67	1.90
(-1.88)(1.89) (12.66)			

E. Transportation

$ETT = 11.24 + .0347TT - 0.354PRDTT$	.970	.73	2.19
(3.83) (9.74) (-1.77)			

F. Construction

$EC = 5.43 + .04C - .156PRDC$	.940	.77	2.32
(6.46)(13.33)(-4.88)			

3. WAGE RATE

A. Manufacturing

WM = 14.04+1.17 WcM-1.38UR .998 7.44 1.17
(-2.57) (60.10) (-2.52)

B. Trade

WT = 2.03+3.33CPIL1-4.93UR .989 8.58 2.36
(.29) (23.24) (-4.40)

C. Finance

WF = -31.57+4.30CPIL1-2.97UR .991 10.81 1.26
(-3.62) (23.85) (-2.10)

D. Services

WS = 7.48+1.05WCS-1.56UR .996 5.97 1.37
(-1.86) (29.29) (-1.62)

E. Transportation

WTT = -37.89+5.57CPIL1-3.99UR .992 13.24 1.38
(-3.55) (25.21) (-2.30)

F. Construction

WC = -20.35+7.44CPIL1-21.12UR .980 22.62 1.96
(-1.12) (19.71) (-7.14)

APPENDIX

VARIABLES NAMES USED IN EMPIRICAL EQUATIONS, HISTORICAL DATA AND ACCOUNTING EQUATIONS

1. Output

M	=	manufacturing output
GNEL1	=	gross national expenditure of Canada for the previous period
MPOP	=	population in the region
ECANWR	=	the Edmonton/Canada wage ratio
ALTDYPC	=	Alberta disposable income per capita
ALTPOP	=	Alberta population
INT	=	interest rate
RINT	=	real interest rate
NCEP	=	net capital expenditures in the oil industry
WOLP	=	world oil price
BL1	=	building permits of the previous period
BL2	=	building permits of two previous periods
T	=	trade output
F	=	finance output
S	=	service output
NCEPL1	=	net capital expenditures in the oil industry from the previous period
TT	=	transportation output
C	=	construction output
YEAR	=	proxy for time

2. Employment

ES	=	employment in services
ET	=	employment in trade
EF	=	employment in finance
ETT	=	employment in transportation
EC	=	employment in construction
EM	=	employment in manufacturing
M	=	manufacturing output

T	=	trade output
F	=	finance output
S	=	services output
TT	=	transportation
WM	=	wage rate in manufacturing
WF	=	wage rate in finance
WT	=	wage rate in trade
WC	=	wage rate in construction
WS	=	wage rate in services
WT	=	wage rate in transportation
WCM	=	wage rate in the Canadian manufacturing industry
WCS	=	wage rate in Canadian services industry
CPI	=	consumer price index
UR	=	unemployment rate
CPIL1	=	consumer price index of the previous period

3. Accounting

TQ	=	total output
TEMP	=	total employment
PRDM	=	productivity in manufacturing
PRDF	=	productivity in finance
PRDTT	=	productivity in transportation
PRDC	=	productivity in construction
ML1	=	manufacturing output from the previous period
FL1	=	finance output from the previous period
TTL1	=	transportation output from the previous period
CL1	=	construction output from the previous period
TWB	=	trade wage bill
SWB	=	service wage bill
MWB	=	manufacturing wage bill
FWB	=	finance wage bill
TTWB	=	transportation wage bill
CWB	=	construction wage bill
FCWB	=	city wide wage bill